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DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION

AERONAUTICAL RESEARCH LABORATORY

MELBOURNE, VICTORIA

Aircraft Structures Technical Memorandum 516

REPORT ON METEOROLOGICAL ASSESSMENT OF BALD HILLS INCIDENTS - PHASE 1

by

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Approved for Public Release

*Monash University Geophysical Fluid Dynamics Laboratory.

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SUMMARY

A number of wind shear events recorded at the Bald Hills tower in Brisbane Australia has been examined and grouped according to cause. The cases include thunderstorms, sea breezes, late night (probably inversion related) incidents, and wave motions.

This work was performed under contract for Aeronautical Research Laboratory by the Geophysical Fluid Dynamics Laboratory, Monash University.

DSTO ARL MELBOURNE

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CONTENTS

1. Introduction

A full description of the Bald Hills data acquisition experiment has been given by Rider et al (1980). These authors have selected from the extensive data archive from the 1976–77 thunderstorm season a number of 'incidents' thought to merit further study. A summary listing of these incidents is given in Table 1, which is reproduced from their report, and the incidents are discussed briefly in their report (Rider et al, 1980).

Data tapes have been supplied to Monash University relating to a further set of incidents identified from the 1977–78 season. A summary table of incidents for this second season has been prepared in the same format as Table 1 and is presented in Table 2. The classification of incidents shown in column 7 of both tables is that specified by ARL and relates to numerical criteria based on certain transducers and is not to be taken as a phenomenological classification.

The purpose of this report is to provide a phenomenological classification of incidents from the 1977–78 season as an extension of that presented already for the 1976–77 season. A few incidents from the 1976–77 season not previously discussed are included in this report.

The number of incidents for each of the five types identified by ARL are shown in the following table 3 for the 1977/78 season, with the corresponding number for the 1976/77 season given in brackets.

Comparison of incidents identified in the 1977/78 and 1976/77 (given in brackets) seasons.

Type of Incidents	Peak wind speed S10				Total all
	0–4.9	5–9.9	10–14.9	15–	speeds
1 (temp drop & squall)	0(0)	5(1)	2(1)	0(5)	7(7)
2 (temp drop only)	9(0)	4(9)	1(1)	0(0)	14(10)
3 (squall only)	3(0)	43(10)	2(7)	0(0)	48(17)
4 (High Shear)	3(0)	17(3)	7(12)	0(0)	27(15)
5 (temp rise)	1(2)	3(1)	0(2)	0(0)	4(5)

It should be noted that the comparison between seasons has been complicated by the fact that different programs were used to identify incidents in the two seasons, and that the peak wind speed for the 1976/77 season is for a 6s average. whereas for 1977/78 [illegible] or a 60s average value.

However, at a given probability level, a 6s average wind speed of 11 ms^{-1} occurs with the same frequency as a 300s average speed of $9ms^{-1}$. It seems unlikely, therefore, that the different distributions of say the 7 type 1 incidents for the two seasons will be much affected by the different averaging times. It is likely that the 1977/78 season was much quieter than the 1976/77 season, but that the improved program used to select incidents resulted in more of the minor incidents being selected in the later year.

2. Classification of Incidents

Incidents from the 1977/78 season have been classified into the following categories:

* thunderstorm events
* late night incidents
* sea breeze incidents
* wave like motions
* miscellaneous

These incidents are classified and summarised in the following sections and tables, but a considerable amount of additional information, including graphical presentations are given in a separate result file.

2.1 Thunderstorms events

These are marked by the following:

* There is usually a substantial temperature drop, (from 2^{0}C to 5^{0}C) and effective mixing takes place so that temperatures at 10m and 100m are quite close,
* In many cases there is a strong vertical downdraft (indicating effective mixing),
* Thunderstorms or outflows from "old" thunderstorms seem mainly to take place mid–afternoon or early evening,
* Incidents seem predominantly from the south, the most common change in wind direction being from northeast to southerly,
* Winds increase for a period (30–60 mins) and then usually drop back to their earlier magnitude, unlike the situation with the onset of the sea–breeze, where there is not such a strong wind speed increase, but the increase is steady and much longer in duration.

Incidents (See Table 3)

C416x .003
C416x .005
C418x .001
C502x .002
C514x .001
C526x .001

2.2 Late Night Incidents

These are marked by the following:

* There are quite distinct wind surges, wind increase of 5–10m/s, duration ~10–25 mins.
* The time of occurrence is between 2200–0020 most commonly ~2300
* An interesting characteristic is that the direction of flow at ground level is usually different from that of flow at 50m and above. The flow is southerly suggesting drainage flow from surrounding hills.
* There are wind surges are from various directions – westerly, north–westerly, easterly.
* The temperature is usually fairly constant or a slight temperature drop (1–2^{o}C).

Incidents (See Table 4)

C413x .001
C415x .003
C418x .003
C428x .001
C438x .002
C489x .001
C507x .002
C526x .003

2.3 Sea Breeze Incidents

These are marked by the following:

* There is a change of wind direction, wind from north, north–east

* The wind speed increases, but not to such a large extent as in the case of thunderstorm outflows. The increase is usually of the magnitude 4 → 6m/s

* The duration of the change is usually quite prolonged i.e. ≥ 60 mins

* Substantial mixing does not appear to take place. A temperature drop of 2–3^{0}C may take place but the temperature at 100m is in most cases still 2–2.5^{0}C lower than that at 10m.

* The onset of sea–breeze is usually mid–morning 1010–1140

Incidents (See Table 5)

C410x .001
C410x .001
C416x .001
C419x .001
C535x .002
C469x .002
C505x .002
C509x .002
C539x .002

2.4 Wave Like Motions

These interesting incidents show wave patterns which, in some cases, becomes more clear cut at greater heights on the tower.

Incidents (See Table 6)

C418x .002
C508x .001

2.5 Miscellaneous

These are incidents in which no change or no well defined change occurred.

DISCUSSION

Up to now work at Monash has concentrated on finding various large scale flow structures which have been observed to move across the Bald Hills site. These include thunderstorms, gust fronts, density currents, sea breezes and waves in the atmosphere. Because these are large scale structures they cause protracted changes in wind conditions and so may be described by an aircraft pilot as wind shear occurrences.

There are also a large number of incidents, which have been classified here among the miscellaneous incidents, where the flow is steady on average, but contains repeated strong fluctuations. Most of these incidents are probably fair weather convection.

Spillane and Hess (1987) have indicated that in a three year study of light aircraft and helicopter accidents weather is a possible factor in 20% of those accidents. The breakdown of weather types and their relative implication is:

Moist convection:	2%
Wind shear:	8%
Dry convection	10%
Total	20%

so the miscellaneous incidents would appear to deserve further study. In fact Hess et al (1987) have indicated that repeated quite large organised structures (only occasionally made visible as dust devils) may be involved in fair weather convection. An aircraft encounter with such a structure will again result in a "wind shear" type experience, but because of the lack of any visual clue it is unlikely to be identified as such. In this connection, McCarthy et al (1979) have suggested that the severity of many wind shear situations lies in their excitation of the phugoid oscillation of an aircraft. McCarthy et al have shown (see their Fig 2) that even a half wave pulse of wind speed, if tuned to the phugoid period, can excite the phugoid oscillation quite strongly. Many of the wind speed graphs shown by Rider et al for strong dry convection have rapid rises in wind speed for which the duration of the rise is comparable to half a phugoid period. The rise is then maintained for 1 to 5 minutes, giving conditions equally likely to excite the phugoid.

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TABLE 1

Incidents Chosen for Study

1 Date	2 Start Time	3 T	4 Dur. Inc. Min.	5 Tape No.	6 Ident.	7 Cla.	8 Squall at 1	2	3	4	9 High Shear A	B	C	10 Temp. D	R	11 Temp. Drop °C	12 Peak Wind Speed	13 Vert. Wind Up/Down	14 Peak Shear	15 Peak 2 min. Rain
1976																				
12 Nov.	2050	T	120	203	122042	3		1	1		1						11·6	2·63/1·24	10·5	
13 Nov.	0859	T	60	203	130851	1	1	1	1	1	1	1		1		4·3	15·4	3·43/1·99	9·5	2
13 Nov.	2131		60	204	132119	1	1	1	1	1	1			1		3·0	15·8	3·64/2·68	9·8	4·3
14 Nov.	0627		60	204	140615	3		1	1	1							9·4	1·95/1·73	6·4	0·3
15 Nov.	0419		60	205	150403	(3)			1								6·2	1·11/0·62	5·4	
15 Nov.	0948		60	205	150932	3			1	1							10·1	3·07/1·74	5·9	
15 Nov.	1307		60	205	151251	3	1	1	1	1							10·4	2·63/2·41	6·8	
15 Nov.	1705		260	206	151704	4					1	1	1				11·2	4·84/2·34	8·5	
16 Nov.	1305		60	207	161246	4					1						12·5	3·19/2·71	8·0	
21 Nov.	1150	T	60	212	211100	3		1	1	1							8·0	1·87/1·56	4·8	7·1
21 Nov.	1436	T	60	212	211346	3		1	1								6·5	1·39/0·74	4·4	3·3
23 Nov.	1758		60	214	231702	2								1		4·9	5·8	2·76/1·02	5·1	
26 Nov.	1721	T	60	217	261619	1	2	2	2	2	1	1		1		2·9	16·5	3·11/2·96	7·9	2
28 Nov.	1124	T	60	219	281012	2								1		4·9	8·3	2·43/1·24	3·7	1·3
30 Nov.	1554	T	60	221	301423	1	2	2	2	1	1	1		1		11·5	24·9	4·69/1·73	14·2	2·3
4 Dec.	1654	T	120	225	341524	1	1	1	1	1	1	1	1	1		5·2	17·7	5·74/2·92	7·9	2·3
5 Dec.	0849		60	226	350714	(3)		1									8·6	2·56/1·56	5·7	
11 Dec.	1231		60	232	411020	2								1			7·4	2·53/1·72	3·7	
12 Dec.	1802	T	180	233	421515	3		1	1	1	1						12·1	2·79/2·85	8·3	
15 Dec.	1547		60	236	451243	4					1						9·9	2·92/1·46	7·7	
16 Dec.	1140		80	237	460833	5					1				1	−2·4	9·7	3·17/2·73	−7·7	
23 Dec.	1034		60	244	530105	2								1		2·2	8·9	2·29/1·37	6·2	0·3
23 Dec.	1513		60	244	531144	(3)		1									7·8	1·73/1·42	6·7	0·8
24 Dec.	0530		60	245	540201	(3)				1							6·1	2·43/1·65	6·2	0·5
24 Dec.	1100		60	245	540731	1		1	1	1				1		4·0	8·1	2·53/1·82	6·4	0·5
28 Dec.	1121		60	249	580751	2								1		2·8	5·0	1·91/1·24	−3·4	
30 Dec.	0955		60	251	600621	5								1	1	−3·6	4·3	3·27/1·62	−2·6	

TABLE 1 (*Continued*)

Incidents Chosen for Study

1 Date	2 Start Time	3 T	4 Dur. Inc. Min.	5 Tape No.	6 Ident.	7 Cla.	8 Squall at 1	2	3	4	9 High Shear A	B	C	10 Temp. D	R	11 Temp. Drop °C	12 Peak Wind Speed	13 Vert. Wind Up/Down	14 Peak Shear	15 Peak 2 min. Rain
1977																				
02 Jan.	1544		90	254	631142	3		1	1								8·9	2·56/1·31	6·7	
04 Jan.	1110		60	256	650649	2			1					1		4·0	10·9	3·36/1·56	6·6	
04 Jan.	1330		60	256	650909	4					1						10·0	3·32/1·97	7·7	
04 Jan.	1803		60	256	651342	4					1						12·0	3·28/1·80	7·5	
07 Jan.	1218		60	259	680750	3	1	1	1	1							10·0	2·38/2·00	6·2	
16 Jan.	1137		60	268	011135	2								1		4·5	8·1	2·31/1·49	4·0	
23 Jan.	1422		180	275	041405	4					1						12·0	3·12/2·53	8·3	
24 Jan.	1145		60	276	051124	2								1		4·4	6·1	2·57/1·65	−3·0	
24 Jan.	1857		60	276	051836	3		1	1	1							8·5	1·71/1·35	5·9	3·3
24 Jan.	2015		60	276	051954	(3)	1				1						12·0	2·85/1·82	8·1	
25 Jan.	1205		180	277	061139	5					1				1	−2·0	11·5	3·90/3·10	8·7	
26 Jan.	1301		60	278	071234	4					1						10·0	3·71/1·72	7·6	
02 Feb.	1202		60	285	141107	4					1						12·5	3·78/1·78	8·4	
02 Feb.	1734		60	285	141639	2								1		2·2	8·8	2·41/1·07	5·3	1·0
02 Feb.	1930		60	285	141835	3		1	1	1	1						10·8	2·97/4·47	10·4	3·6
04 Feb.	0654		60	287	160555	4					1						11·6	2·38/1·85	7·9	0·3
04 Feb.	1148		60	287	161049	4					1						10·3	3·16/1·87	7·5	
07 Feb.	1108		60	290	190958	2								1		2·7	6·5	1·82/1·83	5·3	0·3
11 Feb.	0735		60	294	230613	(3)			1								9·6	2·29/1·65	6·4	
11 Feb.	1056		60	294	230934	4					1						10·5	2·84/1·82	8·1	
12 Feb.	1257		60	295	241132	5					1				1	−2·6	11·1	3·56/1·86	8·0	0·1
12 Feb.	1513		60	295	241348	4					1						10·6	2·85/1·73	7·7	
15 Feb.	1043		60	298	270902	4					1						8·6	3·10/2·19	8·6	
25 Feb.	0957		60	308	370736	5								1	1	−2·2	4·5	1·89/2·65	4·0	
26 Feb.	1443	T	60	309	381222	1		2	2	2	1			1		5·5	12·7	2·20/1·24	8·9	1·0
27 Feb.	1505		140	310	391240	4					1						11·5	3·11/2·10	7·9	
01 Mar.	1625		60	312	411353	4					1						9·4	2·73/2·55	7·8	

Notes on TABLE 1

A figure (usually a 1) in columns 8, 9 or 10 represents an occurrence of the corresponding phenomenon during the course of the incident. A "1" in the squall column indicates that the wind speed rose by at least 5 m/s to at least 7·5 m/s within 9 minutes, and a "2" in the column indicates that the wind speed rose by at least 8 m/s to at least 11 m/s within 9 minutes.

Columns

1	Date of incident
2	Time of start of incident
3	"T" denotes the existence of a simultaneous TAST.
4	Duration of incident in minutes
5	Magnetic tape number
6	Identification at start of incident
7	Classification of incident
8	Squall at level 1 = 10 m, 2 = 50 m, 3 = 100 m, 4 = 150 m
9	High shear between two levels A = 50–10 m, B = 100–50 m, C = 150–100 m
10	Significant temperature drop (D) or rise (R)
11	Magnitude of temperature drop
12	Maximum 6-sec average wind speed (m/s) at 10 m level
13	Max. and min. 6-sec average vert. wind speed at 50 m level
14	6-sec average shear (S_{50}–S_{10}) of maximum magnitude (m/s)
15	Peak 2-minute rainfall in mm.

Classification of incident	*Meaning*
1.	Temperature drop of not less than 2°C in 9 minutes, plus a squall at any two or more levels.
2.	Temperature drop of not less than 2°C but no squall, or a squall at only one level.
3.	A squall at any level(s) but no accompanying temperature drop of significance. A (3) in parentheses indicates that a squall was only noted at one level. Otherwise it occurred at two or more levels.
4.	High shear was observed but no squall or temperature change.
5.	Temperature rise of at least 2°C plus at least one other phenomenon. (A temperature rise without any accompanying phenomenon was ignored.)

TABLE 2 - INCIDENTS DURING 1977/78 SEASON

1 Date	2 Start Time	3 T	4 Dur. Inc. Min.	5 Tape No.	6 Ident.	7 Cla.	8 Squall at 1	2	3	4	5	9 High Shear A	B	C	D	10 Temp. D	R	11 Temp. Drop °C	12 Peak Wind Speed	13 Vert.Wind Up/Down	14 Peak Shear	15 Peak 2 min. Rain
1977																						
Oct 21	0733		60	401	21.07.33	2										1		2.3	3.6	-1.23/1.32	3.2	
26	1247		60	406	26.12.47	(3)					1								5.6	-1.35/0.63	4.8	
30	1028		60	410	30.10.28	2:										1		3.6	6.3	-1.62/0.93	4.0	
31	0741		60	411	31.07.41	3	1		1		1	1							9.2	-1.24/0.66	8.0	
31	1220		60	411	31.12.20	4						1							8.7	-1.64/0.65	7.5	
Nov 3	0005		60	413	34.00.05	3		1	1	1	2								6.1	-0.53/0.48	6.4	
4	1029		60	415	35.10.29	3		1		1	1								7.0	-1.48/0.72	5.8	
4	1355		60	415	35.13.55	4							1						10.8	-1.45/0.40	6.0	
4	2145		60	415	35.21.45	3		1	1	1									5.2	-0.45/0.48	4.9	0.25
5	1040		60	416	36.10.40	3			1		1								8.7	-1.44/0.84	5.3	
5	1322	T	60	416	36.13.22	4						1							11.2	-1.51/0.17	7.6	
5	1457	T	80	416	36.14.57	2						1		1	1	1	1	3.2	11.1	-1.33/0.76	7.7	1.25
5	1630	T	60	416	36.16.30	3		1	1										6.4	-1.11/0	6.3	0.75
5	1910	T	100	416	36.19.10	3	1	2	2	2	2								9.5	-0.85/0.39	6.4	3.5
6	0722		60	417	37.07.22	3		1	1	1	1								6.4	-0.89/0.38	6.6	
6	1746	T	60	417	37.17.46	(3)		1											6.6	-0.86/0.31	6.8	
7	1809	T	60	418	38.18.09	1	1	2	1	2	2	1	1			1		4.8	10.7	-0.93/0.27	10.6	4.6
7	1954		100	418	38.19.54	3	1	1	1	2	1	1							7.8	-0.82/0.31	7.7	0.25
7	2253		60	418	38.22.53	(3)		1											5.4	-0.36/0.22	4.3	0.25
8	1056		60	418	39.10.56	2										1		2.5	4.8	-1.32/1.08	2.9	

TABLE 2 (Continued)

1 Date		2 Start Time	3 T	4 Dur. Inc. Min.	5 Tape No.	6 Ident.	7 Cla.	8 Squall at 1	2	3	4	5	9 High Shear A	B	C	D	10 Temp. D	R	11 Temp. Drop °C	12 Peak Wind Speed	13 Vert.Wind Up/Down	14 Peak Shear	15 Peak 2 min. Rain
	10	1649		100	421	41.16.49	4						1		1					10.1	-0.86/0.87	7.7	
	10	2138		60	421	41.21.38	4								1					4.4	-0.25/0.28	4.1	
	12	1151		430	423	43.11.51	4						1							11.4	-2.07/0.61	10.2	
	13	2200		60	424	44.22.00	3		1	1	1	1								6.8	-0.94/0.12	7.0	
	14	2303		120	425	45.23.03	3		1	2	1	2	1	1						7.6	-1.52/0.36	7.7	0.25
	17	2245		60	428	48.22.45	3		1	1			1							6.1	-2.07/1.08	10.1	1.0
Nov	21	1718		60	432	52.17.18	3		1	1	1	1								7.1	-0.76/0.59	5.8	0.25
	25	0020		60	435	56.00.20	3				1	1								3.1	-0.23/0.10	3.8	
	25	2314		60	436	56.23.14	(3)				1									5.0	-0.44/0.19	4.1	
	26	0651		60	437	57.06.51	3		1	1	1									6.2	-1.01/0.45	6.0	
	26	1307		180	437	57.13.07	4						1							9.8	-2.35/5.2	9.3	
	27	1635		120	438	58.16.35	4						1							8.4	-1.67/0.37	7.8	
	27	2324		60	438	58.23.24	3		1	1										6.8	-1.23/0.12	5.9	0.5
Dec	4	1126		60	445	65.11.26	3	1	1	1			1							9.8	-1.77/0.49	7.9	
	4	1251		60	445	65.12.51	4						1							9.4	-1.82/0.32	7.8	
	11	1713	T	60	452	72.17.13	3		1	1	1	1								6.7	-0.75/0.48	7.0	0.25
	18	0929		140	459	79.09.29	3		1	1	1									8.3	-1.70/1.18	6.7	
	18	1229		60	459	79.12.29	3			1	1				1					7.8	-1.40/0.78	-6.1/6.0	
	18	1529	T	90	459	79.15.29	3		1	1	1		1		1					7.9	-1.53/0.75	8.3	
	23	1314		300	464	84.13.14	4						1							11.4	-2.19/0.82	9.4	
	26	2129		60	467	87.21.29	3				1	1								8.1	-0.74/0.42	5.7	
	28	0735		60	469	89.07.35	3		1	1	1									6.6	-1.77/0.89	4.6	
	28	0950		60	469	89.09.50	2										.1		5.2	8.3	-2.00/0.72	-5.8/5.5	
	28	1509		280	469	89.15.09	4						1	1						10.6	-1.81/0.94	9.9	

TABLE 2 (Continued)

1 Date	2 Start Time	3 T	4 Dur. Inc. Min	5 Tape No.	6 Ident.	7. Cla.	8 Squall at 1	2	3	4	5	9 High Shear A	B	C	D	10 Temp. D	R	11 Temp. Drop °C	12 Peak Wind Speed	13 Vert.Wind Up/Down	14 Peak Shear	15 Peak 2 min. Rain
Jan 3	2019		60	475	95.20.19	3			2		2								8.3	-0.68/0.49	6.1	0.25
7	0754		60	479	99.07.54	2										1		2.5	3.3	-1.44/1.06	-3.0/2.8	
7	0922		60	479	99.09.22	2										1		2.8	4.4	-1.89/1.76	3.6	
8	1428		180	480	00.14.28	(3)					1	1							10.7	-2.23/0.57	8.9	
11	0909		100	483	03.09.09	5										1	1	3.0	5.1	-1.85/0.97	3.9	
11	1434		200	483	03.14.34	1	1	2	2	2	2	1	1			1		3.7	11.6	-1.51/0.49	9.9	1.0
11	1856		120	483	03.18.56	4						1							9.7	-0.99/0.48	8.4	
16	1003		120	488	08.10.03	5										1	1	3.0	6.9	-1.74/1.50	4.6	
17	2301		60	489	09.23.01	3	1	1	1	1	1								8.6	-1.66/0.10	6.6	1.5
19	0844		120	491	11.08.44	5										1	1	2.5	2.8	-1.65/1.24	3.4	
21	1531		60	493	13.15.31	3		1	1	1	1								7.6	-1.20/0.20	5.6	1.0
26	0547		60	498	18.05.47	4									1				2.0	-0.92/0.42	3.4	
28	1645		60	500	20.16.45	3			1		1								6.7	-0.72/0.28	5.0	0.25
28	2048		60	500	20.20.48	(3)					1								4.4	-0.54/0.31	4.1	0.50
29	2353		60	501	21.23.53	4							1						1.7	-0.33/0.17	3.5	
30	0747		60	502	22.07.47	3		1	1	1	1								6.3	-0.76/0.14	6.1	0.75
30	1358		60	502	22.13.58	1		1	1	2	2					1		2.6	7.3	-1.13/0.70	6.7	0.25
Feb 2	1434		140	505	25.14.34	3		1	1	1	1								7.2	-1.13/0.41	6.0	0.5
2	1956		60	505	25.19.56	3	1	2	2	2	2	1							8.6	-1.08/0.17	9.5	0.5
2	2246		60	505	25.22.46	(3)					1								3.8	-0.57/0.38	3.6	0.25
3	1340		60	506	26.13.40	4						1							7.9	-1.78/0.87	7.5	
4	1246		60	507	27.12.46	1	1									1		3.0	9.3	-2.18/0.53	7.2	0.25
4	2110		60	507	27.21.10	3		1	1	1	1								7.0	-0.92/0.39	5.1	0.25
5	1349		60	508	28.13.49	2										1		3.6	8.5	-1.83/0.87	7.0	
5	1631		60	508	28.1[illegible].31	4						1							10.1	-1.40/0.51	8.6	

TABLE 2 (Continued)

1 Date	2 Start Time	3 T	4 Dur. Inc. Min	5 Tape No.	6 Ident.	Cla.	8 Squall at 1	2	3	4	5	9 High Shear A	B	C	D	10 Temp. D	R	11 Temp. Drop °C	12 Peak Wind Speed	13 Vert. Wind Up/Down	14 Peak Shear	15 Peak 2 min. Rain
6	1408		60	509	29.14.08	2										1		2.3	6.7	-1.43/0.75	-5.1/3.5	
6	1511		120	509	29.15.11	1		1	1							1			6.6	-1.04/1.14	4.8	
7	1120		60	510	30.11.20	(3)		1											5.4	-1.37/0.94	3.2	
7	1325		100	510	30.13.25	5										1	1	5.8	5.4	-1.98/1.05	3.6	
11	1752	T	60	514	34.17.52	3	2	2	2	2	2	1							12.4	-0.90/0.42	8.7	1.0
12	0659		60	515	35.06.59	2										1		2.5	1.7	-0.94/0.40	-2.3/1.0	
14	1055		60	517	37.10.55	4						1							7.3	-1.96/0.97	8.0	
14	1642		60	517	37.16.42	4						1							9.5	-1.48/0.51	7.7	
15	0659		60	518	38.06.59	(3)		1											6.8	-1.05/0.23	6.4	
15	0749		60	518	38.07.49	3		1	1	1									8.2	-0.96/0.34	5.4	0.25
15	1438		150	518	38.14.38	4						1							9.9	-1.80/0.63	9.5	
15	1802		60	518	38.18.02	4						1							7.4	-1.05/0.48	7.6	
20	0837		60	523	43.08.37	2										1		2.5	2.4	-1.26/1.20	-2.7/2.1	
21	1103		60	524	44.11.03	2										1		3.2	3.9	-1.36/1.13	4.6	
23	1018		60	526	46.10.18	1		1	1	1						1		4.4	8.0	-1.36/0.51	6.1	1.75
23	1424		60	526	46.14.24	2										1		3.7	4.9	-1.75/0.81	-4.4/4.3	
23	2144		60	526	46.21.44	3	1	2	1	2	2	1							8.5	-0.76/0.12	8.7	1.50
23	2240		60	526	46.22.40	1	1	1	1							1		2.3	9.3	-1.04/0.12	5.4	0.25
March 1	1310		60	532	52.13.10	4						1							9.1	-2.08/0.61	9.3	
1	1418		60	532	52.14.18	(3)		1											8.0	-1.32/0.33	7.3	
1	1554		60	532	52.15.54	4						1							8.6	-1.26/0.82	9.2	
3	1434		60	534	54.14.34	4						1							9.1	-1.34/0.40	8.1	
3	1703		60	534	54.17.03	4						1							9.6	-1.09/0.57	7.8	
4	1052		60	535	55.10.52	(3)		1											7.8	-1.89/0.45	6.8	
4	1722		60	535	55.17.22	(3)		1				1							8.8	-0.87/0.48	9.2	0.25
5	1223		120	536	56.12.23	4						1							9.2	-2.40/1.18	9.0	

TABLE 2 (Continued)

1 Date	2 Start Time	3 T	4 Dur. Inc. Min	5 Tape No.	6 Ident.	7 Cla.	8 Squall at					9 High Shear				10 Temp.		11 Temp. Drop °C	12 Peak Wind Speed	13 Vert. Wind Up/Down	14 Peak Shear	15 Peak 2 min. Rain
							1	2	3	4	5	A	B	C	D	D	R					
5	1734		60	536	56.17.34	4						1							7.7	-1.61/0.38	7.5	
8	090[illegible]		60	539	59.09.03	2										1		3.2	3.9	-1.43/1.12	4.5	
8	1300		60	539	59.13.00	3		1	1	1									8.4	-1.29/0.87	7.2	
9	1434		60	540	60.14.34	4						1							7.1	-1.74/0.79	7.6	
10	1003		60	541	61.10.03	3				1	1								6.6	-0.88/0.87	5.7	

TABLE 3 - Thunderstorm Events

FILE NAME	WIND DIRECTION CHANGE		WIND VELOCITY		VERTICAL DOWNDRAFT	TEMPERATURE
	Tower	Ground Array	Tower	Ground Array		
C416 x .003 -1533	nth easterly → sthly	nth easterly → sthly	2m/s → 8m/s → 13m/s	2m/s → 8m/s → 12m/s		10m 26 C → 21.5 C 100m 25 C → 21.5 C
C416 x .055 -1922	nth easterly → sth west later second surge -2016 s.w. → s	nth easterly → sth west w → sthly	4m/s → 13m/s 5m/s → 18m/s	2m/s → 7 m/s 3m/s → 13m/s		10m 23.5 C → 22.5 C 100m 23 C → 22 C 10m 23 C → 22 C 100m 23.5 C → 20.5 C
C418 x .001 -1833	nth easterly → sthly	nth easterly → sthly	5m/s → 18m/s	3m/s → 12m/s		significant temperature drop 10m 23 C → 18 C 100m 22 C → 17.5 C
C502 x .002 -1410	sthly → w	sthly → w	3m/s → 11m/s	3m/s → 7m/s	strong vertical downdraft	10m 25 C → 22.5 C 100m 24 C → 21.5 C (wave-like motion)
C514 x .001 -1804	nth easterly → sthly	nth easterly → s.w (sthly)	2m/s → 17m/s	2m/s → 13m/s		10m 27 C → 22 C 100m 26 C → 22 C
C526 x .001	s.e. → sthly not a sharp change	s.e. → westerly	4m/s → 10m/s	4m/s → 8m/s		significant temperature drop 10m 27 C → 22 C → 23.5 C 100m 25 C → 22.5 C → 24 C

TABLE 4 - Late Night Incidents

FILE NAME	WIND DIRECTION CHANGE		WIND VELOCITY		VERTICAL DOWNDRAFT	TEMPERATURE
	Tower	Ground Array	Tower	Ground Array		
C413 x .001 ~ 0017	nth → westerly sth.easterly sthly	sthly → s.east. → sthly ~0029	2m/s → 12m/s 3m/s → 12m/s	2m/s → 7m/s → 3m/s → 5m/s	need graph	10m 21 C → 19.5 C → 22 C 100m 22 C → 21.5 C
C415 x .003 ~2157	sth east → nth west → w → e	sth east → nth west → w → se	4m/s → 10m/s	3m/s → 5m/s		~2212 10m 22.5 C → 21.5 C 100m consistantly 21.5 C
C418 x .003 ~2307	nth east → nth west → sth s.w.	s → n.w. → s.w.	2m/s → 7-8m/s	2m/s → 5m/s		temp. fairly consistant 10m 23 C 100m 28.5 C
C428 x .001 ~2300	nth east → w → nth east ~2304	sth → west → nth east	4m/s → 9m/s ~2259	2m/s → 7m/s		slight temp drop 10m 20.5 C → 20 C → 19 C 100m 21 C → 20 C → 19 C ~2259
C438 x .002 ~2336	(slight change) east → sth → east east ~2332	s.e. tending towards s.w.	5m/s → 11m/s	2m/s → 8m/s		~2336 10m 19.5 C → 18 C 100m 20 C → 18 C
C489 x .001 ~2315	nth east → tending slightly more easterly	n.e. → easterly	5m/s → 13m/s (pronounced wind surge duration 6 mins)	2m/s → 9m/s	strong vertical winds	10m 24 C → 23 C 100m 23.5 C → 22.5 C
C507 x .002 ~2124	sth east → east → sth east	sth → east → sth	6m/s → 11m/s	2m/s → 7m/s		10m 22 C → 20.5 C 100m 22 C → 20 C
C526 x .003 ~2156	east → nth east → east	sth → east → sth	6m/s → 13m/s	2m/s → 9m/s		10m 23 C → 22 C 100m 23 C → 22.5 C → 24 C

TABLE 5 - Sea Breeze Incidents

FILE NAME	WIND DIRECTION CHANGE		WIND VELOCITY		VERTICAL DOWNDRAFT	TEMPERATURE
	Tower	Ground Array	Tower	Ground Array		
C410 x .001 ~1040	nth west → nth east	nth west → e (nth east)	2m/s → 5-6m/s	graph		10m 30 C → 27 C 100m 28.5 → 25.5 C
C415 x .001 ~1137	nth west → nth east	nth west → nth east	no significant velocity increase 6-8m/s	6-8m/s		slight temperature decrease 10m 29 C → 28 C 100m 27.5C → 26.5 C
C416 x .001 ~1049	nth west → nth east	nth west → nth east	3m/s → 9m/s	3m s → 7m/s		temp. decrease 10m 30 C → 29 C 100m 29 C → 27 C
C419 x .001 ~1106	west → east	west → east	2m/s → 6m/s			10m 28.5 C → 26.5 C 100m 27.5 C → 25 C
evening sea-breeze C535 x .002 ~1734	sth east → east	sth east → east	7-14m/s	5m/s → 9m/s		10m 23.5 C → 20.5 C 100m 22 C → 20 C
C469 x .002 ~1002	w → easterly	w → easterly	1m/s → 6m/s → 11m/s	4m/s → 7m/s		10m 33 C → 28 C 100m 30 C → 25 C
afternoon shower C505 x .001 ~1446	sth east → e → nth east	sth east → e → nth east	3m/s → 9m/s → 4m/s ~1446	2m/s → 7m/s		10m 25 C → 22 C 100m 24 C → 20.5 C
early evening shower C505 x .002 ~2011	east → nth east	sth east → nth east	5m/s → 13m/s	3m/s → 9m/s	strong vertical downdraft	10m 23.5 C → 20.5 C 100m 22.5 C → 20 C

TABLE 5 - (Continued)

FILE NAME	WIND DIRECTION CHANGE		WIND VELOCITY		VERTICAL DOWNDRAFT	TEMPERATURE
	Tower	Ground Array	Tower	Ground Array		
C509 x .002 .1626	sth → nth east east	sth → east east	2m/s → 8m/s	2m/s → 6 m/s		10m 36 C → 28.5 C 100m 33 C → 26 C
C539 x .002 .1312	nth easterly	nth → easterly east	3m/s → 9m/s	4m/s → 7m/s		10m 27 C → 23 C 100m 24.5 C → 21 C

TABLE 6 - *Wave-like Motions*

FILE NAME	WIND DIRECTION CHANGE		WIND VELOCITY		VERTICAL DOWNDRAFT	TEMPERATURE
	Tower	Ground Array	Tower	Ground Array		
C418 x .002 ~2031	east → nw east→ nw	east → nw sth → nw	10m/s → 3m/s →10m/s → 4m/s → 8m/s	6m/s → 2m/s → 7m/s → 3m/s → 8m/s	graph	10m 18 C → 17.5 C 100m 17 C → 18 C
C508 x .001 ~1403	east → sth east → east → sth east	east → sth east → sth → sth east	10m/s → 14m/s → 7m/s → 13m/s		alot of vertical motion	10m 28 C → 24 C → 27 C → 24.5 C 100m 26 C → 23 C → 25.5 C → 23.5 C

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16. ABSTRACT
A number of wind shear events recorded at the Bald Hills tower in Brisbane Australia has been examined and grouped according to cause. The cases include thunderstorms, sea breezes, late night (probably inversion related) incidents, and wave motions.